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(54) Insulated flowline system.

(57) An insulated flowline system (1) is provided which comprises at least one flowline (3,5,7,9) and an insulation layer substantially surrounding the flowline. The insulation layer includes at least one chamber (12) substantially filled with an insulation composition, said insulation composition comprising a plurality of packed solid particles of lightweight material, whereby a plurality of pores are formed between the particles, which pores are substantially filled with a fluid.

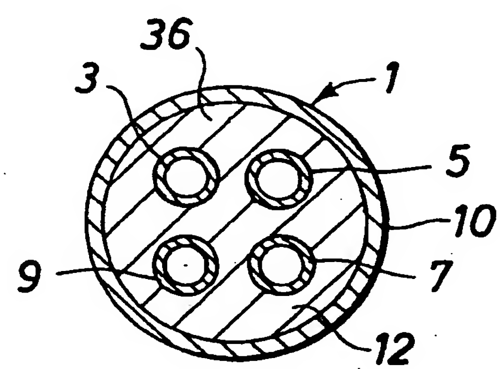

FIG. 2

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The present invention relates to an insulated flowline system. To transport a fluid through a flowline it can be required to thermally insulate the flowline in order to prevent undesired temperature changes of the fluid in the flowline. Adequate insulation is particularly important when hot hydrocarbons are transported through flowlines which are positioned in a cold environment, for example in offshore applications when hot hydrocarbons are transported through flowlines positioned on the seabed. In certain applications the flowlines should also be protected against damage from external forces, for example from the impact of trawler boards on subsea flowlines. Furthermore, such flowlines should be constructed and installed in a cost effective manner.

It is an object of the present invention to provide an insulated flowline system which meets these and other requirements.

In accordance with the invention there is provided an insulated flowline system comprising at least one flowline and an insulation layer substantially surrounding the flowline, which layer includes at least one chamber substantially filled with an insulation composition, said insulation composition comprising a plurality of packed solid particles of lightweight material, whereby a plurality of pores are formed between the particles, which pores are substantially filled with a fluid. The fluid has a high flow resistance in said chamber because of the presence of the particles, so that convection of the fluid through the chamber is substantially reduced. In this manner an insulation composition of particles and stagnant fluid is provided which has adequate insulating properties because of the substantial absence of convection of the fluid. The particles can be packed together without bonding, but if necessary they can be adhesively bonded or thermally fused together to improve the interparticulate shear strength.

In a suitable embodiment of the flowline system according to the invention, said chamber is defined within a carrier pipe, each flowline extending through the carrier pipe in the longitudinal direction thereof, said insulation composition being located between the outer surface of each flowline and the inner surface of the carrier pipe. The flowline system can comprise a single flowline inside the carrier pipe, in which case the chamber forms an annular chamber, or can comprise a plurality of flowlines. In practice the number of flowlines will be less than approximately twenty.

Alternatively, said chamber is defined within a sleeve made of a flexible material, which sleeve is wrapped around the flowline, said insulation composition being located within said sleeve. Suitably, the sleeve is wrapped helically around the flowline. The cross-section of such a wrapped sleeve can have a substantially rectangular shape with a width of between 0.08-0.12 m and a height of between 0.01-0.03 m.

To increase the weight of the flowline system, the fluid suitably comprises a liquid, which liquid can be seawater in case of an offshore flowline system.

Suitable particles, which have adequate insulating properties and sufficient mechanical strength, comprise a polyolefin which may be in the form of a homo- or a copolymer. The particles can be subjected to severe compressive loads during installation or during operation of the flowline system, for example when the system is reeled onto a reel, or when the system is subjected to high hydrostatic forces in an offshore environment. Particles which meet these requirements comprise a composite material, whereby the polyolefin forms the matrix material. The filler can comprise hollow microspheres substantially alone, or in combination with other filler materials, including non-hollow filler materials such as talc, chalk, barium carbonate or chopped glass fibres.

Preferably, the polyolefin is selected from the group of polypropylene and polybutylene. Suitable copolymers are those comprising from 5 to 20 wt% of ethylene as comonomer. The homo- or copolymers may be employed in the form of blends with other polymers, such blends then comprising 1-50 wt%, preferably 10-40 wt% of other polymers such as polyamides and thermoplastic elastomers, e.g. those under the Trade Mark KRATON, and EPDM rubbers.

The flow resistance of the fluid in the pores is adequately high when particles of diameter less than 5 mm are applied, said diameter being suitably between 2 - 4 mm.

The weight of the flowline system remains sufficiently low during transportation or installation thereof when the particles have a density of less than 700 kg/m^3.

Convection of the fluid through the pores between the particles is adequately reduced when the chamber is filled with particles to a volume of between 55-75% of said chamber.

There is further provided a method of creating an insulated flowline system, comprising assembling at least one flowline within a carrier pipe so that the flowline extends through the carrier pipe in the longitudinal direction thereof, whereby a chamber is formed between the outer surface of each flowline and the inner surface of the carrier pipe, transporting the flowline system through a body of water to a selected offshore location, substantially filling said chamber with an insulation composition comprising a plurality of packed solid particles of lightweight material, whereby a plurality of pores are formed between the particles, substantially fill-

ing said pores with a fluid and lowering the system to the seabed. By filling the chamber with the insulation composition at the location of installation, it is achieved that the system is relatively light during transportation thereof. Instead of filling said chamber with the insulation composition at the location of installation only, said chamber can also be filled with a first portion of said particles at the construction site, whereafter the chamber is filled with a second portion of the particles and with the fluid at the location of installation. In this manner a selected buoyancy of the system during transportation thereof through the seawater can be achieved. The invention will now be described by way of example in more detail with reference to the accompanying drawings, in which:

Fig. 1 shows schematically a flowline system which is created with the method according to the invention;

Fig. 2 shows cross-section 2-2 of Figure 1; and

Fig. 3 shows schematically a transverse section of an insulated flowline provided with electric heater cables.

In Figs. 1 and 2 there is shown a flowline system in the form of a flowline bundle 1 for an offshore application, which bundle 1 includes four flowlines 3,5,7,9 for the transportation of hot crude oil or natural gas from a subsea wellhead to a processing facility. The flowlines 3,5,7,9 are arranged inside a carrier pipe 10 whereby a chamber 12 is present between the outer surfaces of the flowlines 3,5,7,9 and the inner surface of the carrier pipe 10. The flowline bundle 1 is to be towed at a controlled depth through the seawater from an onshore construction site to a selected offshore location where the bundle is to be lowered to the seabed.

At the construction site the flowlines 3,5,7,9 are assembled inside the carrier pipe 10 whereby spacers (not shown) are applied between the flowlines 3,5,7,9 and the carrier pipe 10 to keep the flowlines 3,5,7,9 in place. End caps 14,16 are temporarily provided at both ends 18,20 of the carrier pipe 10 to close the ends 18,20 of the carrier pipe 10 and of the flowlines 3,5,7,9. One of the end caps 14 is provided with an inlet 22 for seawater, which inlet 22 is temporarily closed by means of a valve 24. Air vent conduits 26,28 are provided at both end caps 14,16, each air vent conduit 26,28 being temporarily closed by a valve 30,32. The end cap 14 is furthermore provided with an inlet conduit 34 for inserting solid lightweight particles 36 into the chamber 12, which inlet conduit 34 is connected to a compressor 40 for blowing air into the chamber 12 and to a feed conduit 42 for feeding the particles 36 to the inlet conduit 34, the feed conduit 42 being connected to a reservoir 44 in which the particles 36 are stored. The carrier pipe 10 is at the upper side thereof provided with small holes 46 located at regular distances along its length, the holes 46 being smaller in diameter than the diameters of the particles 36. The reservoir 44 is filled with solid lightweight particles 36 made of a composite material of hollow microspheres of inorganic glass embedded in a matrix of polypropylene, which composite material is described in British patent application No. 9017203.2. Such particles typically have a compressive modulus of between 1.1-1.5 GPa at 20 °C, and between 270-300 MPa at 120 °C, and a compressive strength of between 30-40 MPa at 20 °C, and between 8-9 MPa at 120 °C. At least some of the microspheres have been treated with a reagent in the form of an organic peroxide which acts as a chain-scission agent for the polypropylene. Such particles have excellent insulating properties and are capable of withstanding high hydrostatic forces.

A first portion of the particles 36 is inserted into the chamber 12 by operating the compressor 40 which induces a stream of air 50 to flow through the inlet conduit 34 and into the chamber 12. The particles 36 are induced to flow by gravity through the feed conduit 42, and are thereby entrained in the stream of air 50. Thus, the particles 36 are blown with the air from the stream of air 50 into the chamber 12, while the air is vented through the holes 46. When the chamber 12 has been partly filled with particles 36, the compressor 40 is stopped, whereafter the inlet conduit 34 and the holes 46 in the carrier pipe 10 are closed using suitable plugs.

Thereafter the flowline bundle 1 is towed at a controlled depth through the seawater to the desired location. When the flowline bundle 1 has arrived at the selected location, a remaining second portion of the particles is inserted into the chamber in a manner similar to insertion of the first portion into the chamber. Next, the inlet conduit 34 and the holes 46 in the carrier pipe 10 are closed again, and the valves 24,30,32 are opened thereby allowing seawater to flow into the chamber 12 and to fill the pores between the particles 36. The air which is initially present in the pores is thereby vented through the vent conduits 26,28. As the seawater flows into the chamber 12 the weight of the bundle 1 gradually increases, thus promoting the descend of the bundle 1 to the seabed. When the pores are completely filled with seawater, the valves 24,30,32 are closed.

After installation of the bundle 1 on the seabed, the flowlines 3,5,7,9 are connected at their respective ends to other fluid transport facilities (not shown) which do not form part of the present invention.

Instead of applying the inlet conduit which is connected to the end cap, an elongated conduit

which is axially slidable into the chamber can be applied. During filling of the chamber with particles, the elongated conduit is gradually withdrawn from the chamber during filling thereof with particles.

In an alternative installation procedure, the flowline bundle is reeled onto a reel after the particles have been inserted into the chamber between the flowlines and the carrier pipe. To protect the particles from mechanical loads due to reeling of the bundle, helical spacers are arranged between the flowline(s) and the carrier pipe, which spacers are designed to transfer compressive stresses and shear stresses from the carrier pipe to the flowline(s).

Instead of filling the chamber between the particles with seawater, the chamber can be filled with any liquid which does not cause significant deterioration to the particles or pipes and has an adequately low thermal conductivity. The chamber can also be filled with a liquid which solidifies on cooling, for example bitumen or wax, or which can react chemically to form a solid, for example polyurethane.

The insulated flowline system shown in Fig. 3 includes three electric cables 60,62,64 for electrically heating a flowline 66, which cables 60,62,64 extend along at least a substantial part of the length of the flowline 66. The flowline 66 is provided with an anti-corrosion coating 68 of polychloroprene and an insulation layer made of three separate chambers 70,72,74 containing an insulation composition of a plurality of packed solid particles and air present in the pores between the particles. The particles are made of a composite material of a polypropylene matrix in which hollow glass microspheres are embedded. Each chamber 70,72,74 is arranged around a part of the circumference of the flowline 66. The walls 76,78,80 of the respective chambers 70,72,74 are made of polyethylene or from any other suitable material. The chambers 70,72,74 are attached to the flowline 66 by means straps (not shown).

The invention is further illustrated in the following examples:

Example 1

Particles made of hollow glass microspheres embedded in a matrix of polypropylene and having a diameter of 3mm were inserted into an annular chamber formed between a 0.09 m diameter steel pipe and a 0.2 m diameter outer plastic sleeve. The thus insulated pipe was mounted in a horizontal position and heat flow measurements were made on the highest and lowest points at the outside surface of the sleeve when said outside surface was maintained at 25 °C and oil at 95 °C flowed through the steel pipe. Heat flux values of 54 W/m^2 and 50 W/m^2 were measured from the highest and lowest points of the sleeve respectively. The relatively small difference between the measured heat fluxes showed that heat transfer by convection of air through the pores was small.

Example 2

Eight steel flowlines of outer diameter 4.5 inch and wall thickness 0.237 inch, and six steel flowlines of outer diameter 2.375 inch and wall thickness 0.154 inch were assembled in a steel carrier pipe of outer diameter 27.5 inch and wall thickness 0.469 inch. Spherical particles having a diameter of 4 mm, a density of 600 kg/m^3, and a thermal conductivity of 0.14 W/m.K, which particles are made of syntactic foam in the form of the composite material prepared with the method described in British patent application No. 9017203.2, were inserted at the construction site in the chamber between the flowlines and the carrier pipe up to 35 kg/m length. The flowline bundle was then substantially neutral buoyant, and was towed at a controlled depth through the seawater to the desired location where additional particles were inserted up to 93 kg/m length. Subsequently, the pores between the particles were flooded with seawater. The specific weight of the bundle was then 1460 kg/m^3 and the overall thermal conductivity was approximately 0.17 W/m.K.

Example 3

The same flowlines and carrier pipe as in example 1 were used. Spherical beads having a diameter of at maximum 4 mm, a density of 250 kg/m^3, and a thermal conductivity of 0.06 W/m.K, which particles are made of syntactic foam in the form of hollow glass microspheres embedded in a matrix of expanded polystyrene were inserted at the construction site in the chamber between the flowlines and the carrier pipe up to 35 kg/m length. The flowline bundle was then substantially neutral buoyant, and was towed at a controlled depth through the seawater to the desired location where additional particles were inserted up to 53 kg/m length, and the pores between the particles were flooded with seawater. The specific weight of the bundle was then 1260 kg/m^3 and the overall thermal conductivity was approximately 0.08 W/m.K.

Claims

1. An insulated flowline system comprising at least one flowline and an insulation layer substantially surrounding the flowline, which layer includes at least one chamber substantially filled with an insulation composition, said in-

sulation composition comprising a plurality of packed solid particles of lightweight material, whereby a plurality of pores are formed between the particles, which pores are substantially filled with a fluid.

2. The insulated flowline system of claim 1, wherein said chamber is defined within a carrier pipe, each flowline extending through the carrier pipe in the longitudinal direction thereof, said insulation composition being located between the outer surface of each flowline and the inner surface of the carrier pipe.

3. The flowline system of claim 1, wherein said chamber is defined within a sleeve made of a flexible material, which sleeve is arranged around the flowline, said insulation composition being located within said sleeve.

4. The flowline system of any one of claims 1-3, wherein said fluid comprises seawater, and the flowline system forms an offshore flowline system.

5. The flowline system of any one of claims 1-4, wherein said particles include a composite material.

6. The flowline system of claim 5, wherein said composite material includes hollow glass microspheres embedded in a polyolefin matrix material.

7. The flowline system of claim 6, wherein said polyolefin matrix material is selected from the group of polystyrene, polypropylene and polybutylene.

8. The flowline system of any one of claims 1-7, further comprising at least one electric cable for electrically heating said at least one flowline, said cable extending along at least a substantial part of the length of the flowline system.

9. The flowline system of claim 8, wherein said electric cable is arranged between a first and a second of said chambers, each of said chambers being arranged around a part of the circumference of the flowline and extending in the longitudinal direction of the flowline system.

10. A method of creating an insulated flowline system, comprising assembling at least one flowline within a carrier pipe so that the flowline extends through the carrier pipe in the longitudinal direction thereof, whereby a chamber is formed between the outer surface of each flowline and the inner surface of the carrier pipe, transporting the flowline system through a body of water to a selected offshore location, substantially filling said chamber with an insulation composition comprising a plurality of packed solid particles of lightweight material, whereby a plurality of pores are formed between the particles, substantially filling said pores with a fluid and lowering the system to the seabed.

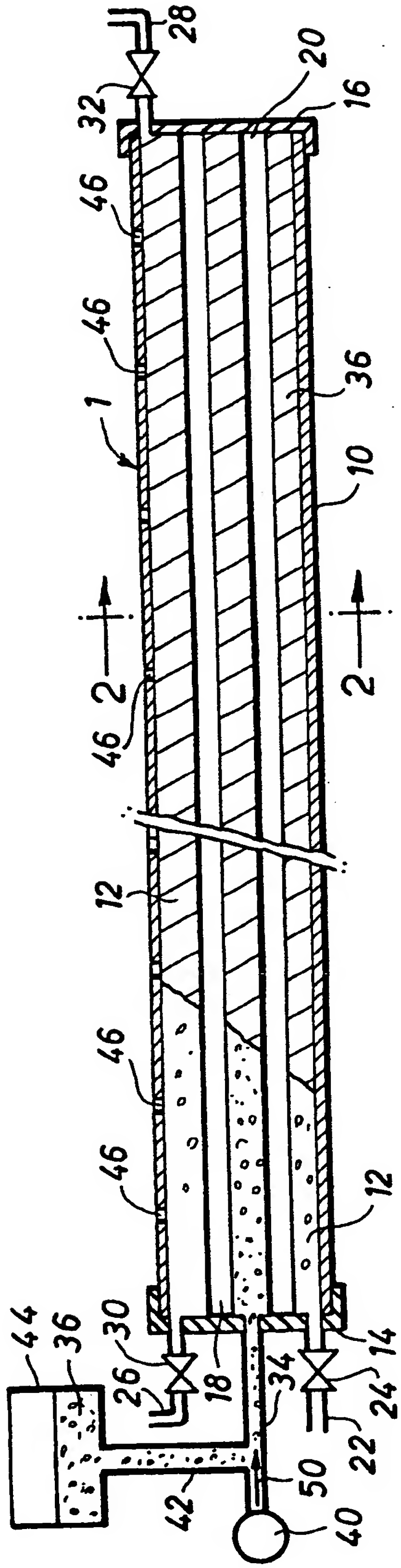
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FIG.1

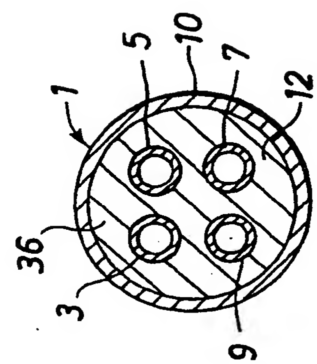
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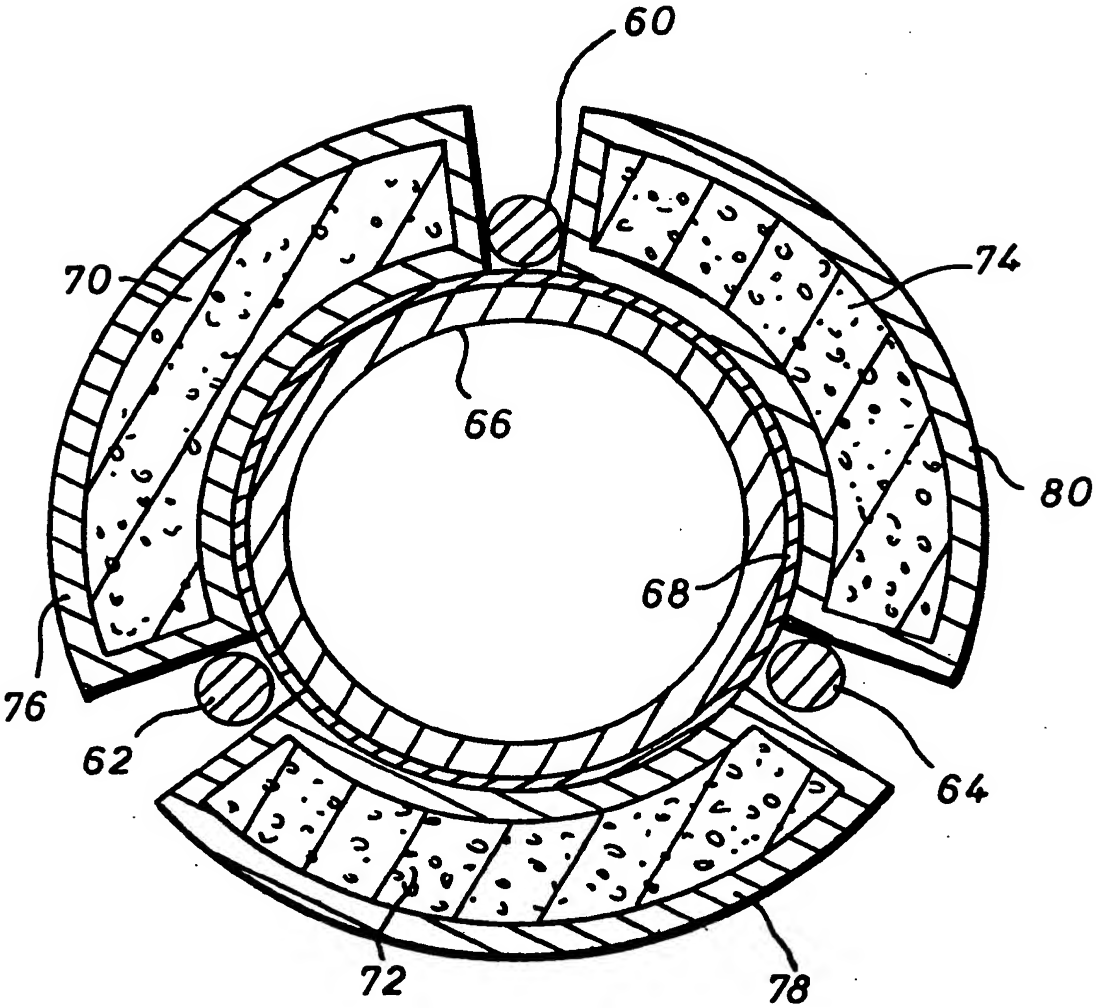
FIG.2

FIG. 3



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EUROPEAN SEARCH REPORT

Application Number

EP 92 20 2015

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
P,A	GB-A-2 247 507 (SEAMARK SYSTEMS) * abstract * ---	1,3,4,5	F16L59/14
A	FR-A-2 479 945 (CHAUDRONNERIE TUYAUTERIE DE BRANGUES CTB) * claims 1,8 * ---	1,8	
A	US-A-3 812 886 (HALLWOOD) * abstract * ---	1	
A	EP-A-0 336 493 (SMIT OFFSHORE CONTRACTORS) ---		
A	US-A-3 719 601 (JACOCKS) -----		

TECHNICAL FIELDS SEARCHED (Int. Cl.5)
F16L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	03 SEPTEMBER 1992	SCHAEFFLER C.A.A.

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